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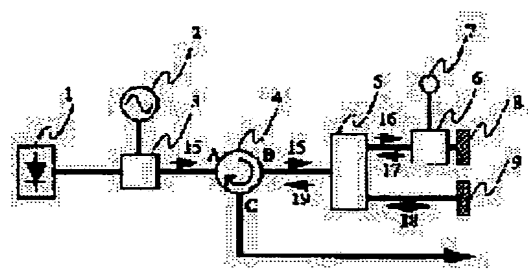
(54) OPTICAL TRANSMITTER

(57)Abstract:

PROBLEM TO BE SOLVED: To provide an optical transmitter with a simple configuration where a degree of suppressing an undesired optical signal can be increased.

SOLUTION: In the optical transmitter where an optical multiplexer/ demultiplexer demultiplexes a wavelength multiplex optical signal 15 consisting of two optical signals generated from the same light source 1 and having different optical frequencies into optical signals 16, 18, one of the demultiplexed signal 16 is optically modulated by using a transmission signal 7, the modulated optical signal 17 and the other optical signal 18 are multiplexed, the multiplexed wavelength multiplex optical signal 19 is transmitted, a receiver side applies heterodyne detection to the signal 19 to receive the modulated transmission signal whose center frequency is a difference of the frequencies of the two optical signals, the one optical signal 17 that is modulated and the other optical signal 18 are respectively reflected to be returned to the optical multiplexer/ demultiplexer 5 that has demultiplexed the original wavelength multiplex optical signal 15, the optical multiplexer/demultiplexer 5 multiplexes the two returned optical signal 17, 18 and an optical circulator 4 demultiplexes the multiplexed wavelength optical signal 19 from the original wavelength multiplex optical signal 15.



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CLAIMS

[Claim(s)]

[Claim 1] The wavelength multiplexing lightwave signal which has the lightwave signal which is two from which it is generated from the same light source, and optical frequency differs is separated spectrally into each lightwave signal with an optical multiplexer/demultiplexer. By [while it was separated spectrally] carrying out light modulation of the lightwave signal by the sending signal, multiplexing this lightwave signal by which light modulation was carried out, and another lightwave signal, transmitting this wavelength multiplexing lightwave signal it was multiplexed [lightwave signal], and carrying out heterodyne detection by the receiving side In the optical transmission device which enabled it to receive the modulating signal of the above-mentioned sending signal which makes center frequency the optical frequency difference of two lightwave signals It returns to the optical multiplexer/demultiplexer with which the lightwave signal and another lightwave signal were reflected, respectively, and while light modulation was carried out [above-mentioned] separated the original wavelength multiplexing lightwave signal spectrally. The optical transmission device characterized by multiplexing two lightwave signals which have returned with this optical multiplexer/demultiplexer, and separating this wavelength multiplexing lightwave signal it was multiplexed [lightwave signal] with the original wavelength multiplexing lightwave signal by the optical circulator.

[Claim 2] The optical transmission device according to claim 1 characterized by carrying out optical amplification of each lightwave signal with the excited rare earth addition optical fiber between the above-mentioned optical circulator and the above-mentioned optical multiplexer/demultiplexer.

[Claim 3] The optical transmission device according to claim 1 characterized by forming the reflective film in the outgoing end of the optical modulator which carries out light modulation of the lightwave signal of the method of top Norikazu.

[Claim 4] The optical transmission device according to claim 1 characterized by making it the polarization condition of the lightwave signal which carried out [above-mentioned] reflection intersect perpendicularly to the polarization condition of the lightwave signal which carried out incidence.

[Translation done.]

* NOTICES *

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention relates to the optical transmission device which carries out optical transmission of the RF signals, such as a millimeter wave, and relates to the optical transmission device which can enlarge whenever [unnecessary lightwave signal oppression] with a simple configuration especially.
[0002]
[Description of the Prior Art] Conventionally, although the waveguide was used as a transmission line, transmission loss is large, and since long-distance transmission is impossible, use of the small optical fiber of transmission loss is considered by millimeter wave band communication system. However, direct intensity modulation of the lightwave signal is carried out with a dozens of GHz millimeter wave band signal, if optical fiber transmission is carried out, the optical spectrum breadth of the modulation lightwave signal by intensity modulation will be large, and will be greatly influenced of the waveform distortion by optical fiber wavelength dispersion, and a transmission distance will be restricted. Then, the optical transmission device as shown in drawing 3 is considered.
[0003] In the optical transmission device of drawing 3 , the single oscillation lightwave signal outputted from the light source 1 is inputted into an optical intensity modulator 3, and intensity modulation is carried out with the millimeter wave signal 2 of frequency F / 2. The optical spectrum of the lightwave signal by which intensity modulation was carried out turns into optical spectrum which has two sidebands in the optical frequency left **F/2 focusing on oscillation optical frequency. The wavelength multiplexing lightwave signal 15 which consists of two lightwave signals with which this optical frequency spacing (optical frequency difference) is set to F is inputted into an optical multiplexer/demultiplexer 13, and is divided into a lightwave signal with the optical spectrum of each sideband. A lightwave signal 16 is inputted into an optical modulator 6, and light modulation of while it dissociated is carried out by the sending signal 7. This lightwave signal 17 by which light modulation was carried out is inputted into an optical multiplexer/demultiplexer 14. Another lightwave signal 18 is inputted into an optical multiplexer/demultiplexer 14 as it is. by the optical multiplexer/demultiplexer 14, while acquires the lightwave signal 17 by which light modulation was carried out, and it is multiplexed in a lightwave signal 18. This wavelength multiplexing lightwave signal 19 is transmitted to a receiving station.
[0004] In a receiving station, the millimeter wave modulating signal which appears as a beat signal in the frequency F which hits the frequency difference of two lightwave signals is receivable by inputting this wavelength multiplexing lightwave signal 19 into an optical receiver, and carrying out heterodyne detection.
[0005] The spectrum of the electrical signal after the optical spectrum of the wavelength multiplexing lightwave signal 19 outputted from an optical multiplexer/demultiplexer 14 was shown in drawing 4 and heterodyne detection was carried out to it at drawing 5 is shown.
[0006] In the wavelength multiplexing lightwave signal 15 generated by carrying out intensity modulation by frequency F / 2, the optical frequency difference of the sideband which appears in

the both sides of optical spectrum is set to F. Two sidebands which serve as this delta frequency F with an optical multiplexer/demultiplexer 13 are once separated separately, light modulation only of the lightwave signal 16 of one sideband is carried out by the sending signal, and the wavelength multiplexing lightwave signal 19 in which this lightwave signal 17 by which light modulation was carried out has only two sidebands shown in drawing 4 by being again multiplexed with the lightwave signal 18 of the sideband with which another side is not modulated is outputted. The Maine subcarrier which appears in the core of the modulated optical spectrum is removed. If heterodyne detection of this wavelength multiplexing lightwave signal 19 is carried out with one optical receiver, as shown in drawing 5 , a beat signal will be received focusing on a frequency F. Since the sideband lightwave signal 18 was not modulated, in this beat signal, only the modulation component of the sideband lightwave signal 17 appears. That is, it becomes the millimeter wave band modulating signal 20 of the center frequency F modulated by the sending signal 7. According to this transmission system, the lightwave signal 18 non-become irregular is not influenced of fiber distribution in response to the effect of distribution of only the modulated lightwave signal 17. Since the frequency of a sending signal 7 is a sufficiently low frequency compared with the center frequency F of the millimeter wave band modulating signal 20, this transmission system carries out direct intensity modulation of the lightwave signal with a millimeter wave band, and the effect of distribution becomes small compared with the method which carries out optical fiber transmission.

[0007] When heterodyne detection is carried out, it is known that the phase noise property of two lightwave signals will become a problem, but in this system, since the lightwave signal of two sidebands which have the same phase noise generated from the one light source is used, a phase noise is offset. Therefore, the signal received is not influenced of a phase noise.

[0008] Here, although how to generate a millimeter wave from the difference frequency of two sideband spectrum was explained, there is also an approach using the output light of the mode locked laser which generates short pulsed light. It is the optical spectrum which has two or more sidebands at ********** spacing, and like the above, after it modulates only one side, an optical multiplexer/demultiplexer can separate two optical spectrum of optical frequency spacing which is equivalent to a desired millimeter wave frequency out of this, multiplex [of the output light of a mode locked laser] is carried out, optical transmission of it can be carried out and it can receive a millimeter wave modulating signal by carrying out heterodyne detection.

[0009] Although the optical multiplexer/demultiplexer 13 used for such an optical transmission device must separate spectrally optically two lightwave signals of the optical frequency difference equivalent to a millimeter wave frequency, when the millimeter wave frequency of 60Hz is converted into the wavelength difference of light in the case of 1550nm of signal light wave length, it is equivalent to about 0.5nm, and this wavelength difference is a value very narrow as a wavelength difference which carries out optical spectral separation, for example. Therefore, it is difficult to oppress enough unnecessary lightwave signals other than the lightwave signal of the request to separate spectrally. therefore, the optical multiplexer/demultiplexer which has the same transmitted wave length property — two steps — or three steps need to connect and it is necessary to enlarge whenever [oppression]

[0010] Moreover, if the external modulator for modulating a lightwave signal has a large insertion loss and an optical multiplexer/demultiplexer is connected to multistage, since the whole insertion loss will also become large, the insertion compensation using an optical amplifier is needed.

[0011]

[Problem(s) to be Solved by the Invention] As mentioned above, in case two sideband lightwave signals are separated spectrally with an optical multiplexer/demultiplexer, in order to enlarge whenever [oppression / of an unnecessary lightwave signal], it is necessary to make multistage connection of the optical multiplexer/demultiplexer. In order to separate the lightwave signal of narrow wavelength spacing spectrally, the transmitted wave length property of an optical multiplexer/demultiplexer will serve as big loss, if transparency core wavelength shifts even when it is steep and small. However, it is very difficult to make correctly in agreement the transmitted wave length of all the optical multiplexer/demultiplexers that make multistage connection, and to

make it stabilize over a long period of time, and it has the problem to which cost also becomes large.
[0012] Then, the purpose of this invention solves the above-mentioned technical problem, and is to offer the optical transmission device which can enlarge whenever [unnecessary lightwave signal oppression] with a simple configuration.
[0013]
[Means for Solving the Problem] The wavelength multiplexing lightwave signal which has the lightwave signal which is two from which this invention is generated from the same light source, and optical frequency differs in order to attain the above-mentioned purpose is separated spectrally into each lightwave signal with an optical multiplexer/demultiplexer. By [while it was separated spectrally] carrying out light modulation of the lightwave signal by the sending signal, multiplexing this lightwave signal by which light modulation was carried out, and another lightwave signal, transmitting this wavelength multiplexing lightwave signal it was multiplexed [lightwave signal], and carrying out heterodyne detection by the receiving side In the optical transmission device which enabled it to receive the modulating signal of the above-mentioned sending signal which makes center frequency the optical frequency difference of two lightwave signals It returns to the optical multiplexer/demultiplexer with which the lightwave signal and another lightwave signal were reflected, respectively, and while light modulation was carried out [above-mentioned] separated the original wavelength multiplexing lightwave signal spectrally. Two lightwave signals which have returned with this optical multiplexer/demultiplexer are multiplexed, and this wavelength multiplexing lightwave signal it was multiplexed [lightwave signal] is separated with the original wavelength multiplexing lightwave signal by the optical circulator.
[0014] Between the above-mentioned optical circulator and the above-mentioned optical multiplexer/demultiplexer, optical amplification of each lightwave signal may be carried out with the excited rare earth addition optical fiber.
[0015] The reflective film may be formed in the outgoing end of the optical modulator which carries out light modulation of the lightwave signal of the method of top Norikazu.
[0016] You may make it the polarization condition of the lightwave signal which carried out [above-mentioned] reflection intersect perpendicularly to the polarization condition of the lightwave signal which carried out incidence.
[0017]
[Embodiment of the Invention] Hereafter, 1 operation gestalt of this invention is explained in full detail based on an accompanying drawing.
[0018] As shown in drawing 1 , the optical transmission device of this invention By carrying out intensity modulation of the light source 1 which outputs a single oscillation lightwave signal, and its single oscillation lightwave signal with the millimeter wave signal 2 of frequency F / 2 It has the terminals A, B, and C of 3 or 3 optical intensity modulators which generate the wavelength multiplexing lightwave signal 15 which has two lightwave signals of the optical frequency difference F. It connects with the terminal B of the optical circulator 4 which has the forward direction transfer characteristics to the terminal C connected to the transmission place from Terminal B and Terminal B from the terminal A connected to the optical intensity modulator 3, and an optical circulator 4. It connects with the 1st outgoing end of the optical multiplexer/demultiplexer 5 which divides the wavelength multiplexing lightwave signal 15 into a lightwave signal with the optical spectrum of each sideband, and an optical multiplexer/demultiplexer 5. It consists of a light reflex machine 9 which while was separated, is connected to the 2nd outgoing end of the optical modulator 6 which carries out light modulation of the lightwave signal 16 by the sending signal 7, the light reflex machine 8 which reflects the output of an optical modulator 6 and is returned to an optical multiplexer/demultiplexer 5, and an optical multiplexer/demultiplexer 5, reflects another [which was separated] lightwave signal 18, and is returned to an optical multiplexer/demultiplexer 5.
[0019] The single oscillation lightwave signal outputted from the light source 1 by this configuration is inputted into an optical intensity modulator 3, and intensity modulation is carried out with the millimeter wave signal 2 of frequency F / 2. The optical spectrum of the lightwave

signal 15 by which intensity modulation was carried out turns into optical spectrum which has two sidebands in the optical frequency left **F/2 focusing on the luminescence frequency. That is, the optical frequency difference of two sidebands is set to F. The wavelength multiplexing lightwave signal 15 which consists of these two lightwave signals is inputted into an optical multiplexer/demultiplexer 5 through Terminal B from the terminal A of an optical circulator 4. A lightwave signal 16 and a lightwave signal 18 are separated by the optical multiplexer/demultiplexer 5. A lightwave signal 16 is inputted into an optical modulator 6, and light modulation of while it dissociated is carried out by the sending signal 7. It is reflected with the light reflex vessel 8, and this lightwave signal 17 by which light modulation was carried out is again returned to the 1st outgoing end of an optical multiplexer/demultiplexer 5 through an optical modulator 6. It is reflected with the light reflex vessel 9, and another lightwave signal 18 is returned to the 1st outgoing end of an optical multiplexer/demultiplexer 5. It is multiplexed in a lightwave signal 17 and a lightwave signal 18 by the optical multiplexer/demultiplexer 5, and this wavelength multiplexing lightwave signal 19 is inputted into the terminal B of an optical circulator 4. The wavelength multiplexing lightwave signal 19 outputted from the terminal C of an optical circulator 4 is transmitted to a receiving station.
[0020] In a receiving station, the millimeter wave modulating signal which appears as a beat signal in the frequency F which hits the frequency difference of two lightwave signals is receivable by inputting this wavelength multiplexing lightwave signal 19 into an optical receiver, and carrying out heterodyne detection.
[0021] Here, since it is reflected by the light reflex machine 8 and the modulation lightwave signal 17 outputted from the optical modulator 6 is again inputted into an optical modulator 6, a duplex will become irregular. Generally, if it becomes irregular to a duplex, the waveform distortion of a modulating signal may occur, but spacing of the light reflex machine 8 and an optical modulator 6 is short enough, and it is satisfactory if a time delay until the lightwave signal 17 outputted from an optical modulator 6 is reflected and it is inputted again is small enough compared with the wavelength of a sending signal 7.
[0022] In the above actuation, an optical multiplexer/demultiplexer 5 will act as a splitter and a multiplexing machine, and two lightwave signals transmitted to a receiving station will penetrate two convenience, respectively. Therefore, whenever [oppression / of an unnecessary lightwave signal] can be doubled by use of one optical multiplexer/demultiplexer 5. Moreover, while the number of an optical multiplexer/demultiplexer decreases compared with the case where two optical multiplexer/demultiplexers are used like the conventional technique, the control circuit for making in agreement the transparency core wavelength of two optical multiplexer/demultiplexers becomes unnecessary, and low-cost-izing of an optical transmission device and improvement in dependability can be aimed at.
[0023] Next, other operation gestalten of this invention are explained.
[0024] As shown in drawing 2 , the optical amplifier is constituted, when the rare earth addition optical fiber 10 is inserted between the terminal B of the optical circulator 4 of the optical transmission device of drawing 1 , and the input edge of an optical multiplexer/demultiplexer 5 and this optical transmission device pours the excitation light from the excitation light source 12 into this rare earth addition optical fiber 10 through the excitation optical multiplexing machine 11.
[0025] With this configuration, since the optical circulator 4 used for the multiplexing/demultiplexing of the I/O lightwave signals 15 and 19 is substituted for the optical isolator of the I/O which is needed in the usual optical amplifier for oscillation prevention, it means an optical isolator's becoming unnecessary and inserting an optical amplifier in low cost by addition of few components. Moreover, since a magnification operation can be given to the lightwave signal 15 inputted into an optical multiplexer/demultiplexer 5, and the lightwave signal 19 of the return outputted from the optical multiplexer/demultiplexer 5, respectively, a property equivalent to the case where two optical amplifiers are inserted is acquired.
[0026] Moreover, in the optical transmission device of drawing 1 and drawing 2 , the light reflex machine 8 can form and constitute the reflective film in the outgoing end of an optical modulator 6. While being able to constitute easily by doing in this way, the time delay by reflection can be

suppressed to the minimum.
[0027] Moreover, in the optical transmission device of drawing 1 and drawing 2 , the light reflex machines 8 and 9 are good to make it the polarization condition of the reflected lightwave signal intersect perpendicularly to the polarization condition of the lightwave signal which carried out incidence. Specifically, the lightwave signal of the polarization condition which intersects perpendicularly to the polarization condition of the lightwave signal which carried out incidence can be reflected by constituting the light reflex machines 8 and 9 from a faraday rotator mirror. Since a polarization condition intersects perpendicularly mutually in the time of spreading toward the time of spreading toward the light reflex machines 8 and 9, and an optical circulator 4, the lightwave signal which passes the optical components between the terminal B of an optical circulator 4 and the light reflex machines 8 and 9 by this can suppress instability, such as output fluctuation of the lightwave signal by polarization dependency loss of these light components etc.

[0028]
[Effect of the Invention] This invention demonstrates the outstanding effectiveness like a degree.
[0029] (1) Since one optical multiplexer/demultiplexer is used as a splitter and a multiplexing machine, whenever [oppression / of an unnecessary lightwave signal] can be enlarged, without increasing the number of an optical multiplexer/demultiplexer.
[0030] (2) The control circuit for making the transparency core wavelength of an optical multiplexer/demultiplexer in agreement becomes unnecessary, and low-cost-izing of an optical transmission device and improvement in dependability can be aimed at.
[0031] (3) Addition of few components can constitute an optical amplifier in low cost.
[0032] (4) By constituting a light reflex machine from a faraday rotator mirror, output fluctuation of the lightwave signal by polarization dependency loss can be suppressed.

[Translation done.]

* NOTICES *

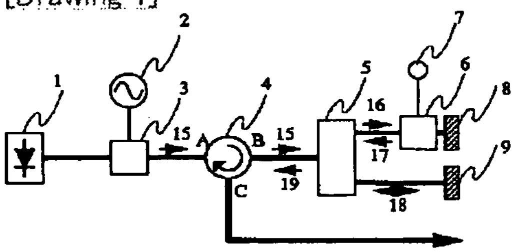
DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] It is the block block diagram of the optical transmission device in which 1 operation gestalt of this invention is shown.
[Drawing 2] It is the block block diagram of the optical transmission device in which other operation gestalten of this invention are shown.
[Drawing 3] It is the block block diagram of the conventional optical transmission device.
[Drawing 4] It is the optical frequency-gain property Fig. showing the optical spectrum of an optical transmission device output.
[Drawing 5] It is the electric frequency-gain property Fig. showing the spectrum of the electrical signal after the heterodyne detection in a receiving station.
[Description of Notations]
1 Light Source
3 Optical Intensity Modulator
4 Optical Circulator
5 Optical Multiplexer/demultiplexer
6 Optical Modulator
8 Light Reflex Machine
9 Light Reflex Machine
10 Rare Earth Addition Optical Fiber
11 Excitation Optical Multiplexing Machine
12 Excitation Light Source

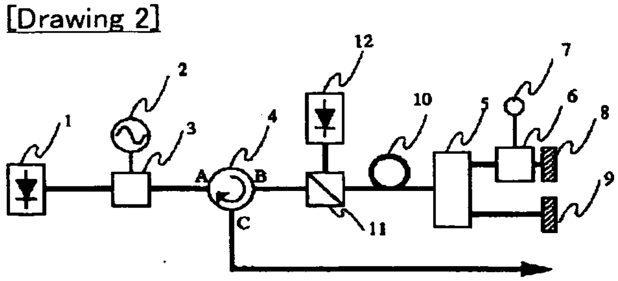
[Translation done.]

DRAWINGS

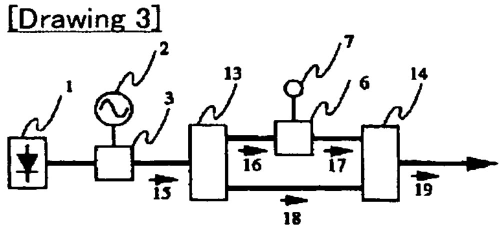
[Drawing 1]



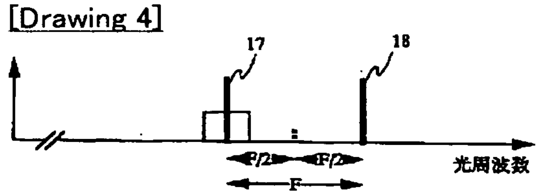
[Drawing 2]



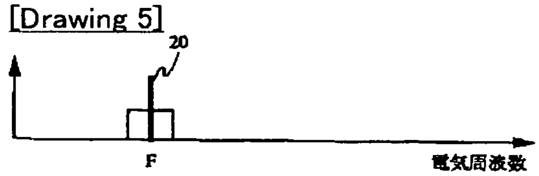
[Drawing 3]



[Drawing 4]



[Drawing 5]



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10/04		Ｈ０４Ｂ　9/00	Ｍ
10/06			
Ｇ０２Ｆ　2/00			

審査請求　未請求　請求項の数４　ＯＬ　（全５頁）　最終頁に続く

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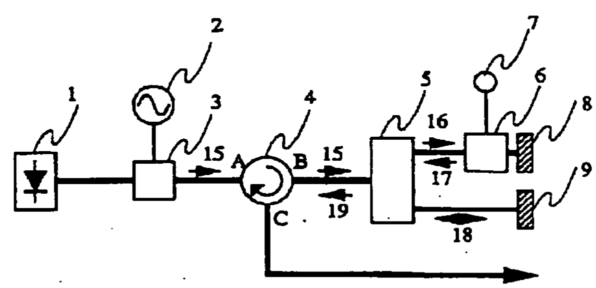
Ｆターム（参考）　2K002 AA02 AB19
5K002 AA02 BA05 CA02 CA07 CA14
DA02 FA01

(54)【発明の名称】　光伝送装置

(57)【要約】
【課題】　簡素な構成で不要光信号抑圧度を大きくできる光伝送装置を提供する。
【解決手段】　同一光源１から生成され光周波数が異なる２つの光信号を有する波長多重光信号１５を光合分波器でそれぞれの光信号１６，１８に分波し、分波された一方の光信号１６を送信信号７により光変調し、この光変調された光信号１７ともう一方の光信号１８とを合波し、この合波された波長多重光信号１９を伝送し、受信側でヘテロダイン検波することにより、２つの光信号の光周波数差を中心周波数とする上記送信信号の変調信号を受信できるようにした光伝送装置において、上記光変調した一方の光信号１７ともう一方の光信号１８とをそれぞれ反射させて元の波長多重光信号１５を分波した光合分波器５に戻し、この光合分波器５で戻ってきた２つの光信号１７，１８を合波し、この合波された波長多重光信号１９を光サーキュレータ４で元の波長多重光信号１５と分離する。



【特許請求の範囲】

【請求項１】　同一光源から生成され光周波数が異なる２つの光信号を有する波長多重光信号を光合分波器でそれぞれの光信号に分波し、分波された一方の光信号を送信信号により光変調し、この光変調された光信号ともう一方の光信号とを合波し、この合波された波長多重光信号を伝送し、受信側でヘテロダイン検波することにより、２つの光信号の光周波数差を中心周波数とする上記送信信号の変調信号を受信できるようにした光伝送装置において、上記光変調した一方の光信号ともう一方の光信号とをそれぞれ反射させて元の波長多重光信号を分波した光合分波器に戻し、この光合分波器で戻ってきた２つの光信号を合波し、この合波された波長多重光信号を光サーキュレータで元の波長多重光信号と分離することを特徴とする光伝送装置。

【請求項２】　上記光サーキュレータと上記光合分波器との間で、励起された希土類添加光ファイバによりそれぞれの光信号を光増幅させることを特徴とする請求項１記載の光伝送装置。

【請求項３】　上記一方の光信号を光変調する光変調器の出力端に反射膜を形成したことを特徴とする請求項１記載の光伝送装置。

【請求項４】　上記反射した光信号の偏波状態が入射した光信号の偏波状態に対して直交するようにしたことを特徴とする請求項１記載の光伝送装置。

【発明の詳細な説明】

【０００１】

【発明の属する技術分野】本発明は、ミリ波等の高周波信号を光伝送する光伝送装置に係り、特に、簡素な構成で不要光信号抑圧度を大きくできる光伝送装置に関するものである。

【０００２】

【従来の技術】従来、ミリ波帯通信システムでは、伝送路として導波管を用いていたが、伝送損失が大きく、長距離伝送ができないので、伝送損失の小さな光ファイバの利用が検討されている。しかし、数十ＧＨｚのミリ波帯信号により光信号を直接強度変調して光ファイバ伝送すると、強度変調による変調光信号の光スペクトラム広がりが大きく、光ファイバ波長分散による波形歪みの影響を大きく受け、伝送距離が制限される。そこで、図３に示すような光伝送装置が考えられている。

【０００３】図３の光伝送装置では、光源１から出力される単一発振光信号は、光強度変調器３に入力され周波数Ｆ／２のミリ波信号２により強度変調される。強度変調された光信号の光スペクトラムは、発振光周波数を中心として±Ｆ／２離れた光周波数に２つの側波帯を有する光スペクトラムとなる。この光周波数間隔（光周波数差）がＦとなる２つの光信号からなる波長多重光信号１５は、光合分波器１３に入力され、それぞれの側波帯の光スペクトラムを持つ光信号に分離される。分離された一方の光信号１６は、光変調器６に入力され、送信信号７により光変調される。この光変調された光信号１７は、光合分波器１４に入力される。もう一方の光信号１８は、そのまま光合分波器１４に入力される。光合分波器１４により、光変調された光信号１７ともう一方の光信号１８とが合波される。この波長多重光信号１９が受信局へ伝送される。

【０００４】受信局においては、この波長多重光信号１９を光受信器へ入力し、ヘテロダイン検波することにより、２つの光信号の周波数差にあたる周波数Ｆにビート信号として現れるミリ波変調信号を受信することができる。

【０００５】図４に、光合分波器１４から出力される波長多重光信号１９の光スペクトラムを示し、図５に、ヘテロダイン検波された後の電気信号のスペクトラムを示す。

【０００６】周波数Ｆ／２で強度変調することにより生成された波長多重光信号１５において、光スペクトラムの両側に現れる側波帯の光周波数差はＦとなる。光合分波器１３によりこの周波数差Ｆとなる２つの側波帯は一旦別々に分離され、一方の側波帯の光信号１６のみが送信信号により光変調され、この光変調された光信号１７がもう一方の変調されていない側波帯の光信号１８と再び合波されることにより、図４に示す２つの側波帯のみを持つ波長多重光信号１９が出力される。変調された光スペクトラムの中心に現れるメイン搬送波は除去される。この波長多重光信号１９を１つの光受信器でヘテロダイン検波すると、図５に示されるように、周波数Ｆを中心にビート信号が受信される。側波帯光信号１８は無変調であるから、このビート信号には側波帯光信号１７の変調成分のみが現れる。つまり、送信信号７により変調された中心周波数Ｆのミリ波帯変調信号２０となる。この伝送方式によれば、変調された光信号１７のみが分散の影響を受け、無変調の光信号１８はファイバ分散の影響を受けない。送信信号７の周波数は、ミリ波帯変調信号２０の中心周波数Ｆに比べて十分低い周波数であるから、この伝送方式は、ミリ波帯で光信号を直接強度変調して光ファイバ伝送する方式に比べて分散の影響が小さくなる。

【０００７】ヘテロダイン検波した場合、２つの光信号の位相雑音特性が問題になることが知られているが、このシステムでは１個の光源から生成した同じ位相雑音を有する２つの側波帯の光信号を使用しているため、位相雑音は相殺される。従って、受信される信号は、位相雑音の影響を受けない。

【０００８】ここでは、２つの側波帯スペクトラムの差周波数からミリ波を発生する方法について説明したが、短パルス光を発生させるモードロックレーザの出力光を用いる方法もある。モードロックレーザの出力光は、等光周波数間隔に複数の側波帯を有する光スペクトラムで

あり、この中から所望のミリ波周波数に相当する光周波数間隔の２つの光スペクトラムを光合分波器により分離し、上記と同様にして、一方のみを変調した後、多重して光伝送し、ヘテロダイン検波することにより、ミリ波変調信号を受信することができる。

【０００９】このような光伝送装置に使用する光合分波器１３は、ミリ波周波数に相当する光周波数差の２つの光信号を光学的に分波しなければならないが、例えば６０Ｈｚというミリ波周波数は、信号光波長１５５０ｎｍの場合、光の波長差に換算すると約０．５ｎｍに相当し、この波長差は、光学的分波する波長差としては非常に狭い値である。従って、分波する所望の光信号以外の不要光信号を十分抑圧することは難しい。そのため、同じ透過波長特性を有する光合分波器を２段あるいは３段接続して、抑圧度を大きくする必要がある。

【００１０】また、光信号を変調するための外部変調器は挿入損失が大きく、光合分波器を多段に接続すると、全体の挿入損失も大きくなるので、光増幅器を用いた挿入補償が必要となる。

【００１１】

【発明が解決しようとする課題】前述したように、光合分波器で２つの側波帯光信号を分波する際、不要光信号の抑圧度を大きくするため光合分波器を多段接続する必要がある。狭い波長間隔の光信号を分波するため、光合分波器の透過波長特性は急峻であり、僅かでも透過中心波長がずれると大きな損失となる。しかし、多段接続する全ての光合分波器の透過波長を正確に一致させ、かつ長期安定化させることは非常に難しく、コストも大きくなる問題がある。

【００１２】そこで、本発明の目的は、上記課題を解決し、簡素な構成で不要光信号抑圧度を大きくできる光伝送装置を提供することにある。

【００１３】

【課題を解決するための手段】上記目的を達成するために本発明は、同一光源から生成され光周波数が異なる２つの光信号を有する波長多重光信号を光合分波器でそれぞれの光信号に分波し、分波された一方の光信号を送信信号により光変調し、この光変調された光信号ともう一方の光信号とを合波し、この合波された波長多重光信号を伝送し、受信側でヘテロダイン検波することにより、２つの光信号の光周波数差を中心周波数とする上記送信信号の変調信号を受信できるようにした光伝送装置において、上記光変調した一方の光信号ともう一方の光信号とをそれぞれ反射させて元の波長多重光信号を分波した光合分波器に戻し、この光合分波器で戻ってきた２つの光信号を合波し、この合波された波長多重光信号を光サーキュレータで元の波長多重光信号と分離するものである。

【００１４】上記光サーキュレータと上記光合分波器との間で、励起された希土類添加光ファイバによりそれぞれの光信号を光増幅させてもよい。

【００１５】上記一方の光信号を光変調する光変調器の出力端に反射膜を形成してもよい。

【００１６】上記反射した光信号の偏波状態が入射した光信号の偏波状態に対して直交するようにしてもよい。

【００１７】

【発明の実施の形態】以下、本発明の一実施形態を添付図面に基づいて詳述する。

【００１８】図１に示されるように、本発明の光伝送装置は、単一発振光信号を出力する光源１、その単一発振光信号を周波数Ｆ／２のミリ波信号２により強度変調することにより、光周波数差Ｆの２つの光信号を有する波長多重光信号１５を生成する光強度変調器３、３つの端子Ａ，Ｂ，Ｃを有し、光強度変調器３に接続された端子Ａから端子Ｂ及び端子Ｂから伝送先に接続された端子Ｃへの順方向伝達特性を有する光サーキュレータ４、光サーキュレータ４の端子Ｂに接続され、波長多重光信号１５をそれぞれの側波帯の光スペクトラムを持つ光信号に分離する光合分波器５、光合分波器５の第１出力端に接続され、分離された一方の光信号１６を送信信号７により光変調する光変調器６、光変調器６の出力を反射して光合分波器５に戻す光反射器８、光合分波器５の第２出力端に接続され、分離されたもう一方の光信号１８を反射して光合分波器５に戻す光反射器９からなる。

【００１９】この構成により、光源１から出力される単一発振光信号は、光強度変調器３に入力され周波数Ｆ／２のミリ波信号２により強度変調される。強度変調された光信号１５の光スペクトラムは、発光周波数を中心として±Ｆ／２離れた光周波数に２つの側波帯を有する光スペクトラムとなる。つまり、２つの側波帯の光周波数差がＦとなる。この２つの光信号からなる波長多重光信号１５は、光サーキュレータ４の端子Ａから端子Ｂを通って光合分波器５に入力される。光合分波器５により光信号１６と光信号１８とが分離される。分離された一方の光信号１６は、光変調器６に入力され、送信信号７により光変調される。この光変調された光信号１７は、光反射器８で反射され、光変調器６を介して再び光合分波器５の第１出力端に戻される。もう一方の光信号１８は、光反射器９で反射され、光合分波器５の第１出力端に戻される。光合分波器５により光信号１７と光信号１８とが合波され、この波長多重光信号１９は、光サーキュレータ４の端子Ｂに入力される。光サーキュレータ４の端子Ｃから出力された波長多重光信号１９は、受信局へ伝送される。

【００２０】受信局においては、この波長多重光信号１９を光受信器へ入力し、ヘテロダイン検波することにより、２つの光信号の周波数差にあたる周波数Ｆにビート信号として現れるミリ波変調信号を受信することができる。

【００２１】ここで、光変調器６から出力された変調光

信号１７は、光反射器８により反射されて再び光変調器６に入力されるため、二重に変調されることになる。一般には、二重に変調を行うと、変調信号の波形歪みが起きる可能性があるが、光反射器８と光変調器６との間隔が十分短く、光変調器６から出力される光信号１７が反射されて再び入力されるまでの遅延時間が送信信号７の波長に比べて十分小さければ問題ない。

【００２２】以上の動作において、光合分波器５は、分波器及び合波器として作用し、受信局へ伝送する２つの光信号が、それぞれ都合２回透過することになる。従って、１個の光合分波器５の使用で不要光信号の抑圧度を２倍にすることができる。また、従来技術のように２個の光合分波器を使用する場合に比べて光合分波器の個数が少なくなると共に、２個の光合分波器の透過中心波長を一致させるための制御回路が不要となり、光伝送装置の低コスト化、信頼性向上を図ることができる。

【００２３】次に、本発明の他の実施形態を説明する。

【００２４】図２に示されるように、この光伝送装置は、図１の光伝送装置の光サーキュレータ４の端子Ｂと光合分波器５の入力端との間に希土類添加光ファイバ１０が挿入され、この希土類添加光ファイバ１０に励起光合波器１１を介して励起光源１２からの励起光を注入することにより光増幅器が構成されている。

【００２５】この構成では、通常の光増幅器において発振防止のために必要となる入出力の光アイソレータは、入出力光信号１５，１９の合分波のために用いた光サーキュレータ４で代用されるため、光アイソレータが不要になり、少ない部品の追加により低コストに光増幅器を挿入したことになる。また、光合分波器５へ入力する光信号１５と光合分波器５から出力された戻りの光信号１９に対してそれぞれ増幅作用を持たせることができるので、光増幅器を２個挿入した場合と同等の特性が得られる。

【００２６】また、図１、図２の光伝送装置において、光反射器８は光変調器６の出力端に反射膜を形成して構成することができる。このようにすることにより簡単に構成できると共に、反射による遅延時間を最小限に抑えることができる。

【００２７】また、図１、図２の光伝送装置において、光反射器８，９は、反射した光信号の偏波状態が入射した光信号の偏波状態に対して直交するようにすると良い。具体的には、光反射器８，９をファラデー・ローテーター・ミラーで構成することにより、入射した光信号の偏波状態に対して直交する偏波状態の光信号を反射させることができる。これにより、光サーキュレータ４の端子Ｂと光反射器８，９との間にある光部品を通過する光信号は、光反射器８，９に向かって伝搬するときと光サーキュレータ４に向かって伝搬するときとで偏波状態が互いに直交するため、これら光部品の偏波依存性損失等による光信号の出力変動などの不安定性を抑えることができる。

【００２８】

【発明の効果】本発明は次の如き優れた効果を発揮する。

【００２９】（１）１個の光合分波器を分波器及び合波器として使用するので、光合分波器の個数を増やすことなく不要光信号の抑圧度を大きくすることができる。

【００３０】（２）光合分波器の透過中心波長を一致させるための制御回路が不要となり、光伝送装置の低コスト化、信頼性向上を図ることができる。

【００３１】（３）少ない部品の追加により低コストに光増幅器を構成することができる。

【００３２】（４）光反射器をファラデー・ローテーター・ミラーで構成することにより、偏波依存性損失による光信号の出力変動を抑えることができる。

【図面の簡単な説明】

【図１】本発明の一実施形態を示す光伝送装置のブロック構成図である。

【図２】本発明の他の実施形態を示す光伝送装置のブロック構成図である。

【図３】従来の光伝送装置のブロック構成図である。

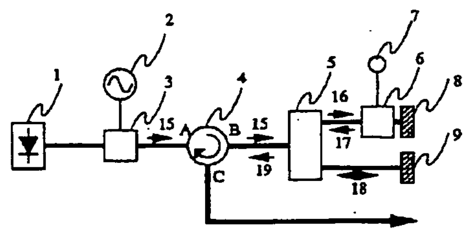
【図４】光伝送装置出力の光スペクトラムを示す光周波数－利得特性図である。

【図５】受信局におけるヘテロダイン検波後の電気信号のスペクトラムを示す電気周波数－利得特性図である。

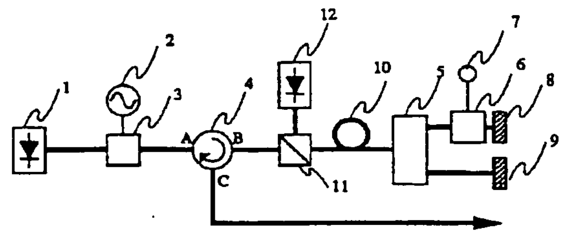
【符号の説明】

1　光源
3　光強度変調器
4　光サーキュレータ
5　光合分波器
6　光変調器
8　光反射器
9　光反射器
１０　希土類添加光ファイバ
１１　励起光合波器
１２　励起光源

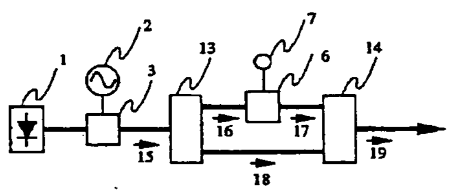
【図1】



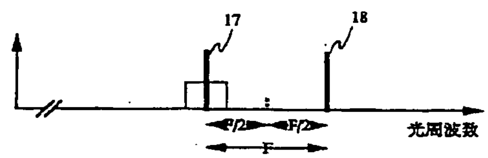
【図2】



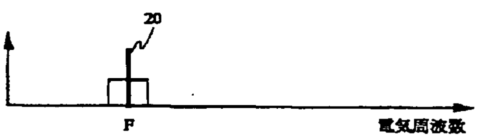
【図3】



【図4】



【図5】



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